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Kinetic asymmetries during running in male youth

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ABSTRACT

Objectives: A possible injury risk factor is limb asymmetry, which may differ across maturation given the adult growth spurt. The aim of this study is to quantify the magnitude of asymmetry in a number of kinetic variables during a running task in male youth of different maturity status.
Design: Quantitative observational laboratory study.
Setting: Sports performance laboratory.
Participants: Non-injured youth athletes in pre-, mid-, and post-pubescent status.
Main outcome measures: Inter-limb leg asymmetries whilst sprinting on a non-motorized treadmill. Percent asymmetry was defined as: (Left leg − right leg)/right leg*100 = %asymmetry.
Results: Horizontal force presented limb asymmetries of 15.4, 14.8 and 14.7% for the pre-, mid- and post-PHV group respectively. Values for vertical force were higher (18.1, 20.2 and 20.8% respectively). Power asymmetries were 14.9, 15.8, and 15.5% respectively and work asymmetries were significant higher in pre-PHV participants (26.4%) compared to mid- (14.7%) and post-PHV (17.3%) participants.
Conclusions: As the population in this study was characterized as non-injured, asymmetries of 15–20% appeared typical during a running task in developmental athletes.

1. Introduction

With every training session and competitive event, athletes are at risk of injury. To decrease the likelihood of athlete injury, coaching staff implement various types of screens to identify possible risk factors. One possible risk factor identified in the literature is lower limb asymmetry, which has been proven to impact the incidence of injuries (Croisier, Forthomme, Namurois, Vanderthommen, & Crielaard, 2002; Knapik, Bauman, Jones, Harris, & Vaughn, 1991; Orchard, Marsden, Lord, & Garlick, 1997; Yamamoto, 1993).

Testing for leg asymmetry can be performed utilizing acyclic and cyclic methods. Acyclic asymmetries are usually quantified via a unilateral jumping task such as a vertical or horizontal jump (Flanagan & Harrison, 2007; Hoffman, Ratamess, Klatt, Faigenbaum, & Kang, 2007; Impellizzeri, Rampinini, Maffiuletti, & Marcora, 2007; Newton et al., 2006) or dynamometers (Croisier et al., 2002; Impellizzeri et al., 2007; Newton et al., 2006; Orchard et al., 1997; Rahnama, Lees, & Bambaecichi, 2005). Cyclic assessments used to determine the magnitude of asymmetry have included: consecutive jumping (Flanagan & Harrison, 2007) and running assessments (Bachman, Heise, & Bressel, 1999; Belli, Lacour, Komi, Candau, & Denis, 1995; Brughelli, Cronin, Mendiguchia, Kinsella, & Nosaka, 2010; Dalleau, Belli, Bourdin, & Lacour, 1998; Vagenas & Hoshizaki, 1992) performed on motorized and non-motorized treadmills and force plates.

With regards to cyclic assessments, the asymmetry associated with a variety of variables whilst jumping and running has been reported. Differences of 1.3–4.2% for flight time, reactive strength index, vertical stiffness and peak vertical force have been reported for consecutive jumping (Flanagan & Harrison, 2007). Leg asymmetries of 3.5% for contact time (Brughelli et al., 2010), 4.2–16.7% for leg stiffness (Bachman et al., 1999; Brughelli et al., 2010; Dalleau

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et al., 1998), 6.5–12.6% for vertical stiffness (Bachman et al., 1999; Brughelli et al., 2010), 0.9% for negative work (Dalleau et al., 1998), 10.7% for positive work (Brughelli et al., 2010), 1.1–3.7% for step time (Belli et al., 1995), 3.7–11.6% for displacement (Belli et al., 1995; Brughelli et al., 2010; Vagenas & Hoshizaki, 1992), and 46.3% (Brughelli et al., 2010) have been reported whilst running.

All the research discussed thus far has quantified the magnitude of asymmetry in adult participants. With the increase in elite sports academies in schools and many clubs identifying and developing talent at an early age, it would seem logical to screen developing athletes for leg asymmetries as well. The testing should preferably involve the main activity of the sports, such as running for football or field-hockey or jumping for volleyball, netball or basketball. However, studies quantifying asymmetry in children and/or youth athletes (Chin, So, Yuan, Li, & Wong, 1994; Teixeira, Silva, & Carvalho, 2003; Teixeira & Teixeira, 2008) are rare, and no researchers to the author's knowledge have quantified asymmetry whilst running in youths. Certainly asymmetry has not been investigated with regard to youth athletes of different maturity status. This would seem important given the rise of hormone levels (testosterone and growth hormones) associated with puberty (Forbes, Bullers, Lovell, McNaughton, Polman, & Siegler, 2009; Fraisier, Gafford, & Horton, 1969; Kraemer, 1988; Ramos, Frontera, Llopart, & Feliciano, 1998; Round, Jones, Honour, & Nevill, 1999) around peak height velocity (PHV) and the large improvements in strength (Mero, Kauhanen, Peltola, Vuorimaa, & Komi, 1990), and consequently power output (Armstrong, Welsman, & Chia, 2001; Armstrong, Welsman, Williams, & Kirby, 2000; Forbes et al., 2009; Ioakimidis, Gerodimos, Kellis, Alexandris, & Kellis, 2004; Mero et al., 1990). In addition and inherent with those changes in physical performance, it is thought that muscle and ligaments cannot keep pace with bone growth especially around the athlete's growth spurt, causing decreased flexibility and muscle imbalances (d'Hemecourt, Zurakowski, Kriemler, & Micheli, 2002; Purcell & Micheli, 2009), which in turn can increase incidence of injury, as evidenced in youth soccer players (Le Gall, Carling, & Reilly, 2007). Given this information it is hypothesized that the magnitude of asymmetry will be greater in more mature athletes, the purpose of this study therefore to quantify the magnitude of asymmetry in a number of kinetic variables during a running task in male youth of different maturity status.

2. Methods

2.1. Participants

Two invitation letters for participation in this investigation were sent to a) the national sport school and b) a high school that has a specific focus on excellence in sport. The principals discussed the possible participation with the sport directors and thereafter provided suitable participants. One hundred and twenty-two male athletes between 8 and 16 years of age volunteered to participate in this study. All participants were physically active, trained a minimum of two times per week for their sport, represented their club and/or school at a regional and/or national level and were involved in sports (soccer, field hockey, sprinting, distance running) where running/sprinting was an important component of their performance. The participants were further divided into three maturational groups (Rumpf, Cronin, Pinder, Oliver, & Hughes, 2012). The first group consisted of the pre-pubescent (≤12 years of age = pre-peak height velocity PHV), the second of the mid-pubescent (13–15 years of age = mid-PHV) and the last of the post-pubescent (≥16 years of age = post-PHV) athletes. Participant characteristics can be observed in Table 1. All participants and their legal guardians were informed of the risks and benefits of participation and both legal guardians and participants provided written informed consent and assent to participate in this study. Procedures were approved by the Ethics Committee of the AUT-University.

Table 1
Participant characteristics according to their maturation status.

	Age (years)	Maturation offset (years)	Height (cm)	Mass (kg)	BMI (kg/m^2)
	Mean ± Std	Mean ± Std	Mean ± Std	Mean ± Std	Mean ± Std
Pre-PHV ($N = 41$)	10.5 ± 1.37	−2.95 ± 0.92	141 ± 7.85	36.2 ± 10.2	17.9 ± 3.48
Mid-PHV ($N = 30$)	14.5 ± 0.93	0.36 ± 0.52	166 ± 6.93	55.2 ± 6.59	19.4 ± 4.19
Post-PHV ($N = 51$)	15.4 ± 0.74	1.79 ± 0.56	178 ± 8.22	70.4 ± 13.3	22.3 ± 3.55

2.2. Equipment

Running performance was assessed using a non-motorized force treadmill (Woodway, Weil am Rhein, Germany) in conjunction with the Pacer Performance Software (Fittech, Australia). The participants wore a harness around their waist, which was connected to a non-elastic tether. The tether was connected to a horizontal load cell (Model BS-500 Class III, Transcell Technology Inc, Buffalo Grave, USA), which measured horizontal force. The height of the load cell was adjusted accordingly to the subject's height, so that the tether was horizontal during testing. Vertical force was measured by four individual vertical load cells that were mounted under the running surface. The entire system was calibrated using a range of known weights. Vertical and horizontal force was collected at a sampling rate of 200 Hz with a cut-off frequency of 4 Hz. Treadmill belt velocity was monitored by two optical speed photomicrosensors, collected by a tachometer XPV7 PCB (Fitness Technology, Adelaide, Australia), and analyzed with the Pacer Performance software (Fitness Technology, Australia).

2.3. Procedures

Data collection sessions were standardized around mode of training and daily structure. Before physical testing, anthropometric measurements were taken. The height (cm), sitting height (cm), mass (kg) were measured and the body mass index (BMI) calculated. To calculate the maturity status of participants, a maturity index (i.e. timing of maturation) was calculated using the equation of Mirwald, Baxter-Jones, Bailey, and Beunen (2002): Maturity Offset $= -9.236 + (0.0002708 \times \text{leg length} \times \text{sitting height}) + (-0.001663 \times \text{age} \times \text{leg length}) + (0.007216 \times \text{age} \times \text{sitting height}) + (0.02292 \times \text{weight by height ratio})$. This assessment is a non-invasive and practical method of predicting years from PHV as a measure of maturity offset using anthropometric variables. The standard error of estimate for PHV was 0.49 years for boys (Mirwald et al., 2002).

Participants then received a familiarization session on the non-motorized treadmill, which consisted of standing, walking and running at a self-chosen speed. The familiarization was also used as a warm-up phase (~10 min). If the participants were unable to run freely, without holding on to the frame of the treadmill, the data collection was postponed and further familiarization took place. Otherwise, a series of warm-up sprints on the treadmill i.e. 3 × 5 s preceded the data collection. The fastest two from three sprints over a 30 m distance from a standing split start were then collected and used for data analysis. A four minute rest was scheduled after each trial.